02-23-00 A

NEW, CONTINUATION, DIVISIONAL OR CONTINUATION-IN-PART APPLICATION UNDER 37 C.F.R. §1.53(b)

Attorney Docket No. 6550-000043

Express Mail Label No. EJ689142715US

Date February 22, 2000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Hon. Commissioner of Patents and Trademarks
Washington, D. C. 20231

Sir:

Transmitted herewith for filing under 37 C.F.R §1.53(b) is a patent application for **A Process for High Fidelity Sound Recording and Reproduction of Musical Sound.**

identified by: [ ] First named inventor _____
or [X]Attorney Docket No. (see above)

1. **Type of Application**

[X] This application is a new (non-continuing) application.

[ ] This application is a [ ] continuation / [ ] divisional / [ ] continuation-in-part of prior application No. ____. Amend the specification by inserting before the first line the sentence:

--This is a [continuation/division/continuation-in-part] of United States patent application No. ____, filed ____.--

[ ] The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied, is considered part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

If for some reason applicant has not requested a sufficient extension of time in the parent application, and/or has not paid a sufficient fee for any necessary response in the parent application and/or for the extension of time necessary to prevent the abandonment of the parent application prior to the filing of this application, please consider this as a Request for an Extension for the required time period and/or authorization to charge our Deposit Account No. 08-0750 for any fee that may be due. THIS FORM IS BEING FILED IN TRIPLICATE: one copy for this application; one copy for use in connection with the Deposit Account (if applicable); and one copy for the above-mentioned parent application (if any extension of time is necessary).

2. **Contents of Application**

a. Specification of **21** pages;
[ ] A microfiche computer program (Appendix);
[ ] A nucleotide and/or amino acid sequence submission;

[ ] Because the enclosed application is in a non-English language, a verified English translation [ ] is enclosed [ ] will be filed.

[ ] Cancel original claims ____ of the prior application before calculating the filing fee. (At least one original independent claim must be retained for filing date purposes.)

b. [X] Drawings on **7** sheets;

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c. [X] A signed Oath/Declaration [X] is enclosed / [ ] will be filed in accordance with 37 C.F.R. §1.53(f).

The enclosed Oath/Declaration is [X] newly executed / [ ] a copy from a prior application under 37 C.F.R. §1.63(d) / [ ] accompanied by a statement requesting the deletion of person(s) not inventors in the continuing application.

d. **Fees**

FILING FEE CALCULATION	Number Filed		Number Extra		Rate		Basic Fee $690.00
Total Claims	20 –	20 =	0	×	$18.00	=	
Independent Claims	3 –	3 =	0	×	$78.00	=	
Multiple Dependent Claim(s) Used					$260.00	=	
FILING FEE – NON-SMALL ENTITY							
FILING FEE - SMALL ENTITY: Reduction by 1/2 [X] Verified Statement under 37 C.F.R. §1.27 is enclosed. [ ] Verified Statement filed in prior application.							$345.00
Assignment Recordal Fee ($40.00)							40.00
37 C.F.R. §1.17(k) Fee (non-English application)							
TOTAL							**$385.00**

[X] A check is enclosed to cover the calculated fees. The Commissioner is hereby authorized to charge any additional fees that may be required, or credit any overpayment, to Deposit Account No. 08-0750. A duplicate copy of this document is enclosed.

[ ] The calculated fees will be paid within the time allotted for completion of the filing requirements.

[ ] The calculated fees are to be charged to Deposit Account No. 08-0750. The Commissioner is hereby authorized to charge any additional fees that may be required, or credit any overpayment, to said Deposit Account. A duplicate copy of this document is enclosed.

3. **Priority Information**

[ ] **Foreign Priority**: Priority based on _____ Application No. _____, filed _____, is claimed.

[ ] A copy of the above referenced priority document [ ] is enclosed / [ ] will be filed in due course, pursuant to 35 U.S.C. §119(a)-(d).

[ ] **Provisional Application Priority**: Priority based on United States Provisional Application No. ____, filed ____, is claimed under 35 U.S.C. §119(e).

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4. **Other Submissions**

[ ] A Preliminary Amendment is enclosed.

[X] An Information Disclosure Statement, **1** sheets of PTO Form 1449, and **1** patent(s)/publications/documents are enclosed.

[X] A power of attorney

[X] is submitted [X] with the new Oath/Declaration.

[ ] is of record in the prior application and [ ] is in the original papers / [ ] a copy is enclosed.

[X] An Assignment of the invention

[X] is enclosed with a cover sheet pursuant to 37 C.F.R. §§3.11, 3.28 and 3.31.

[ ] is of record in a prior application. The assignment is to ____, and is recorded at Reel ____, Frame(s) ____.

[X] An Establishment of Assignee's Right To Prosecute Application Under 37 C.F.R. §3.73(b), and Power Of Attorney is enclosed.

[X] An Express Mailing Certificate is enclosed.

[X] Other: Return postcard.

Attention is directed to the fact that the correspondence address for this application is:

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Respectfully,

Date February 22 2000
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Date February 22, 2000

Hon. Commissioner of Patents
and Trademarks
Washington, D.C. 20231

Sir:

EXPRESS MAILING CERTIFICATE

Applicant: William M. Hartmann

Serial No (if any): Not assigned yet

For: A PROCESS FOR HIGH FIDELITY SOUND RECORDING AND REPRODUCTION OF MUSICAL SOUND

Docket: 6550-000043

Attorney: Ronald L. Hofer

"Express Mail" Mailing Label Number EJ689142715US

Date of Deposit ..... February 22, 2000

I hereby certify and verify that the accompanying $385.00 check ($345.00) for filing fee and $40.00 for Recordal Fee); 3-page transmittal letter (in duplicate); for New Patent Application (21 pages); 7 sheets of drawings (showing Figures 1-14); 2-page Declaration and Power of Attorney; 2-page cover sheet for Recordal of Document (in duplicate) with 1-page Assignment; 2-page Verified Statement (Declaration) Claiming Small Entity Status, Nonprofit Organization; 2-page Establishment of Assignee's Right to Prosecute Application and Power of Attorney; 2-page Information Disclosure Statement; 1-page PTO Form 1449 with 1 patent document; and return postcard; along with this Express Mailing Certificate are being deposited with the United States Postal Service "Express Mail Post Office To Addressee" service under 37 C.F.R. 1.10 on the date indicated above and (is) are addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Lillian L. Egnoski

Signature of Person Mailing Document(s)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s) or Patentee: William M. Hartmann
Serial or Patent No.: Not yet assigned
Filed or Issued: Herewith
For: A Process For High Fidelity Sound Recording And Reproduction Of Musical Sound

Attorney Docket No.: 6550-000043

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(d)) - NONPROFIT ORGANIZATION

I hereby declare that I am an official empowered to act on behalf of the nonprofit organization identified below:

NAME OF ORGANIZATION: Board of Trustees operating Michigan State University

ADDRESS OF ORGANIZATION: East Lansing, Michigan 48824

TYPE OF ORGANIZATION:

[XX] University or other institution of higher education
[ ] Tax exempt under Internal Revenue Service Code (26 USC 501(a) and 501(c)(3))
[ ] Nonprofit scientific or educational under statute of state of The United States of America

(Name of state: _____)

(Citation of statute: _____)

[ ] Would qualify as tax exempt under Internal Revenue Service Code (26 USC 501(a) and 501(c)(3)) if located in The United States of America
[ ] Would qualify as nonprofit scientific or educational under statute of state of The United States of America if located in The United States of America

(Name of state: _____)

(Citation of statute: _____)

I hereby declare that the nonprofit organization identified above qualifies as a nonprofit organization as defined in 37 CFR 1.9(e) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code with regard to the invention entitled

A PROCESS FOR HIGH FIDELITY SOUND RECORDING AND REPRODUCTION OF MUSICAL SOUND

by inventor(s) William M. Hartmann, described in

[X] the specification filed herewith
[ ] application serial no. _____, filed _____.
[ ] patent no. _____ issued _____

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) AND 1.27(d)) - NONPROFIT ORGANIZATION

I hereby declare that rights under contract or law have been conveyed to and remain with the nonprofit organization with regard to the above-identified invention.

If the rights held by the nonprofit organization are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who could not qualify as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

NAME: _____

ADDRESS: _____

_____

[ ] Individual [ ] Small Business Concern [ ] Nonprofit Organization

NAME: _____

ADDRESS: _____

_____

[ ] Individual [ ] Small Business Concern [ ] Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Name of Person Signing: Daniel T. Evon

Title in Organization: Director, Contracts and Grants

Address of Person Signing: 301 Administration Bldg.
Michigan State University
East Lansing, Michigan 48824

Signature: Daniel T. Evon Date: 2/15/00

A PROCESS FOR HIGH FIDELITY SOUND RECORDING AND REPRODUCTION OF MUSICAL SOUND

A PROCESS FOR HIGH FIDELITY SOUND RECORDING AND REPRODUCTION OF MUSICAL SOUND

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to sound recording and reproduction systems. More particularly, the present invention relates to local performance simulation.

2. Discussion of the Related Art

Sound recording and reproduction has long been the subject of research, development and debate. Conventional stereophonic practices create a musical environment for the listener by including recording environment information, specifically early reflections and reverberation. Recording engineers therefore pay close attention to the recording hall and the location of the microphones when they record ensembles. When the original recording has inadequate environment information, such information is typically added artificially through electronic reverb boxes and ambience synthesizers. Artificial addition is essential when the original recording is made electronically or by tight-miking techniques.

The value of replacing recording environment effects with the actual effects of the listing environment, therefore, have largely gone overlooked. There are many circumstances, however, in which it is quite desirable to simulate a "local performance." For example, there is a small but significant market of classical music connoisseurs who would greatly value the experience of a string quartet playing in the comfort of their own homes. Another benefit of local performance simulation is the possibility of elimination of intermodulation (IM) distortion between the tones of different instruments. Because the tones of a

musical instrument tend to be harmonic, local performance simulation would limit distortion to harmonic distortion only, causing only a slight change in coloration for the instrument.

It is also desirable to provide the ability to highlight a particular musical instrument in an ensemble for educational purposes. Similarly, local performance simulation would allow the tone color of each instrument to be varied to taste. For instance, when listening to a simulated quartet, the listener could elect to give the second violin a darker tone color to exaggerate the difference between it and the first violin. There is also a need to individually shut off any instrument of the ensemble to provide a "music-minus-n" system. The local performance technique would allow the performer to feel that the other musicians of the ensemble are with her and around her, in the same listening environment. Furthermore, because each instrument would be recorded separately, editing of recordings and processing of individual voices would be facilitated. Errors by one musician could be corrected without the participation of the other musicians. It is also desirable to optimize loudspeakers for their particular functions. This would eliminate the present need, for example, for a large low-frequency driver (woofer) in the system that is dedicated to a flute. Dedicating loudspeaker systems would therefore control the cost of multi-channel ensembles.

Present stereophonic practice sometimes attempts to localize sound images, but localization is psychoacoustically fragile. This means that present audio imaging approaches depend on the loudspeakers, listening environment, and listener position used by the ultimate consumer. Adding to the difficulty is the fact that the principle function of stereo is to de-localize the sounds from the loudspeaker positions themselves and to provide a broadened image. In other

words, stereophonic recording by definition attempts to bring the listener into the recording environment instead of bringing the musical performance into the listening environment. Furthermore, conventional stereophonic sound reproduction and contemporary surround sound techniques require the listener to be in a particular place or area. It is thus desirable to provide a sound recording and reproduction system with accurate imaging capability. This capability would allow the listener to perceive the individual instruments or voices to be spatially compact, and well-localized in azimuth, elevation and distance. Furthermore, it would be desirable to allow the listener to walk entirely around the synthesized performing ensemble.

SUMMARY OF THE INVENTION

In view of the above, a need exists for a system capable of accurately simulating the radiation pattern of each instrument in an ensemble. Accordingly, the present invention provides a method and system for simulating an ensemble sound pattern. The local performance simulation system includes a signal generation system for simultaneously generating contact recording signals based on vibrations from an ensemble, where the ensemble produces an audible ensemble sound pattern. A signal processing system channelizes the contact recording signals and generates final instrument signals based on the channelized contact recording signals. The simulation system further includes a reproduction system for generating audible sound waves based on the final instrument signals, where the sound waves simulate the ensemble sound pattern.

Thus, the method includes the steps of simultaneously generating contact recording signals based on vibrations from the ensemble, where the ensemble

produces an audible ensemble sound pattern. The contact recording signals are channelized, and final instrument signals are generated based on the channelized contact recording signals. The method further provides for generating audible sound waves with a reproduction system based on the final instrument signals, where the sound waves simulate the ensemble sound pattern.

In another aspect of the invention, a method for tuning a local performance simulation system is provided. The tuning method includes the steps of matching a system overall frequency response to a known overall frequency response, and matching a system coarse asymmetrical frequency response to a known coarse asymmetrical frequency response. A system fine asymmetrical frequency response is further matched to a known fine asymmetrical frequency response. The system overall frequency response, system coarse asymmetrical frequency response and system fine asymmetrical frequency response simulate a frequency response of an audible ensemble sound pattern produced by an ensemble.

Further objects, features and advantages of the invention will become apparent from a consideration of the following description and the appended claims when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and feature of this invention will become further apparent from a reading of the following detailed description taken in conjunction with the drawings, in which:

Figure 1 is a block diagram of a local performance simulation system according to the preferred embodiment of the present invention;

Figure 2 is a perspective view of a string quartet according to the preferred embodiment of the present invention;

Figure 3 is a block diagram of a signal generation system according to the present invention;

Figure 4 is a perspective view of a pair of contact transducers as applied to a cello according to the present invention;

Figure 5 is a block diagram of a signal processing system according to the present invention;

Figure 6 is a block diagram of a storage system for a signal processing system according to the present invention;

Figure 7 is a block diagram of a retrieval system for a signal processing system according to the present invention;

Figure 8 is a perspective view of a reproduction system according to a preferred embodiment of the present invention;

Figure 9 is a sectional top view of a loudspeaker system according to the present invention;

Figure 10 is a flowchart of a process for tuning a local performance simulation system according to the present invention;

Figure 11 is a flowchart of a process for matching overall frequency response according to the present invention;

Figure 12 is a flowchart of a process for matching coarse asymmetrical frequency response according to the present invention;

Figure 13 is a flowchart of a process for matching fine asymmetrical frequency response according to the present invention; and

Figure 14 is a block diagram demonstrating the process of matching overall frequency response according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As illustrated in Figure 1, a local performance simulation system 20 simulates an ensemble sound pattern by producing sound waves which simulate the ensemble sound pattern. The simulation system 20 has a signal generation system 30, a signal processing system 50, and a reproduction system 70. The signal generation system 30 simultaneously generates contact recording signals based on vibrations from an ensemble 21, where the ensemble 21 produces an audible ensemble sound pattern. The signal processing system 50 channelizes the contact recording signals and generates final instrument signals based on the channelized contact recording signals. The simulation system 20 further includes a reproduction system 70 for generating audible sound waves based on the final instrument signals, where the sound waves simulate the ensemble sound pattern. The reproduction system 70 therefore uses the reflection and reverberation effects of the listening environment to create the perception that the ensemble 21 is present and that the ensemble sound pattern is being generated from within the listening environment.

Preferably, the ensemble sound pattern emanates from a plurality of instruments, and as shown in Figure 2, the preferred embodiment simulates a string quartet 21'. It will be appreciated that while it is preferred to simulate a string quartet 21', other instruments such as brass or wind instruments can be simulated without parting from the spirit and scope of the invention. As shown in Figure 3, the signal generation system 30 preferably includes a plurality of

contact recording configurations 31 for converting the vibrations from ensemble 21 into contact recording signals. Figure 4 demonstrates that each contact recording configuration 31 preferably includes a pair of contact transducers coupled to a corresponding instrument 22. The location of each contact transducer is governed by listening tests and cross-correlation function measurements in different frequency bands at different locations. Specifically, each pair of contact transducers includes a first transducer 32 located below an F-hole 23 of the corresponding instrument 22. The first transducer 32 generates a contact recording signal based on vibrations near the F-hole 23. A second contact transducer 33 is located under a bridge 24 of the corresponding instrument 22. Similarly, the second transducer 33 generates a contact recording signal based on vibrations near the bridge 24. As will be discussed below, the signals from the transducers 32, 33 are simultaneously recorded to separate channels using sound recording techniques well known in the art. Thus, two channels per instrument are created in the preferred embodiment.

Turning now to Figure 5, the preferred signal processing system 51 is shown in greater detail. The signal processing system 50 includes a storage system 51 for storing the contact recording signals to a storage medium 53 as channelized data. A retrieval system 52 retrieves the channelized data from the storage medium 53. It will be appreciated that storage medium 53 is preferably a computer readable medium such as a CD-ROM or DVD. As shown in Figure 6, it is preferred that the storage system 51 include an analog to digital conversion system 54 for generating digital recording signals based on the contact recording signals from the signal generation system 30. A recording system 55 generates the channelized data based on the digital recording signals and records the

channelized data to the storage medium 53. The signals are therefore maintained on separate channels throughout the simulation process. It will further be appreciated that as shown in Figure 7, the retrieval system 52 of the signal processing system 50 preferably includes an equalization system 56 for tailoring a frequency response of the channelized data. A mixing system 57 generates intermediate instrument signals based on the channelized data. The preferred retrieval system 52 further includes a digital to analog conversion system 58 for generating final instrument signals based on the intermediate instrument signals. Thus, amplifier 59 can amplify the final instrument signals for transmission to the reproduction system 70.

The reproduction system 70 will now be described in greater detail. Figure 8 demonstrates that the reproduction system 70 includes a plurality of loudspeaker systems 71, 72, 73 and 74. It is preferred that each loudspeaker system 71, 72, 73 and 74 has an assigned instrument and generates audible sound waves which approximate a frequency dependence of sound wave radiation from front, back and side surfaces of the assigned instrument. As best seen in Figure 9, the reproduction system 70 may also include a means for simulating musician absorption of the audible sound waves such as absorption panel 75. It can further be seen that each loudspeaker system includes at least one front driver 76 having a predetermined front piston diameter for approximating the frequency dependence of radiation from front and side surfaces of the assigned instrument. Figure 9 further demonstrates that a second front driver 77 can also be provided. Furthermore, as cost considerations permit, loudspeaker systems can have side drivers 78, 79 to further increase accuracy of the simulation. As will be discussed later, each instrument has an asymmetrical

frequency response. This asymmetrical frequency response is essentially an angular dependence of radiation from all surfaces of the instrument. Angular dependence can be matched in its coarse structure and approximated in its fine structure.

It will be appreciated that the simulation system 20 matches the simulation coarse angular dependence to a reference coarse angular dependence by two techniques. First, the frequency dependence of the radiation from front and back surfaces is approximated by using separate loudspeaker drivers. Thus, back driver 80 has a predetermined rear piston diameter for approximating the frequency dependence of radiation from back and side surfaces of the assigned instrument. Furthermore, front drivers 76, 77 reproduce radiation in the forward direction of the assigned instrument. The second matching technique approximates the polar radiation pattern. The polar pattern on radiation is approximated by using drivers with a piston diameter that reproduces the low-frequency lobe in the forward direction. For example, at an angle of 90 degrees the radiation from a viola is down 3 dB at a frequency of 1000 Hz. According to well-known theories for the radiation of a piston in an infinite baffle, a polar pattern with that characteristic requires a piston diameter of about 22 cm. The use of separate drivers 76, 77, 78. 79, 80 is further improved with the deployment of front and back equalizers (not shown) at the input to each driver 76, 77, 78, 79, 80.

Turning now to Figure 10, a method for tuning a local performance simulation system to the required frequency responses is shown in greater detail. Specifically, at step 100, the system overall frequency response is matched to a known overall frequency response. The method further includes the step 200 of

matching the system coarse asymmetrical frequency response and step 300 of approximating the system fine asymmetrical frequency response. Figure 11 shows step 100 in greater detail. It can be seen that at step 101 an instrument is selected from the ensemble. The musician then plays scales at step 102, and contact and acoustic microphone recordings are simultaneously made at steps 103 and 104, respectively. At step 105, the equalizer is adjusted so that the overall frequency response of the simulation, measured in one-third-octave bands approximates the overall frequency response of the microphone recording. Figure 14 demonstrates that recordings are made with contact recording configurations 31 as usual and, using a separate recorder, with acoustical microphones 25. In constructing the listening system, the loudspeakers are adjusted so that when they reproduce the signals from the contact transducers 31, the long-term spectrum measured with the same acoustical microphones 25 and the same reverberant environment matches the original recordings. Perceptually important spectral structures in the real instruments will be captured by the third-octave matching technique.

As noted above, each instrument also has an asymmetrical frequency response which has an angular dependence. With respect to coarse structures, the overall directional frequency response of musical instruments has been measured in anechoic rooms by many workers. For example, Jurgen Meyer has measured the angular dependence of the frequency response for many orchestral instruments including the violin, viola and cello. These responses appear in his 1978 textbook entitled "Acoustics and the Performance of Music".

Turning now to Figure 12, the process of matching coarse asymmetrical frequency response is shown in greater detail. At step 201, the instrument is

selected and at step 202, the reference coarse angular dependence is determined. The reproduction of the contact recording is matched to the reference at step 203 by the loudspeaker design techniques described above.

As shown in Figure 13, the present invention also provides for matching the fine asymmetrical frequency response. The fine structure of the radiation pattern of a musical instrument is complicated. For violins, the fine structure is different from violin to violin. The result of the fine structure is that when the musician plays changing notes, the different high frequency harmonics are radiated in directions that change dramatically. This effect lends interest to the sound of the instrument and the tone is perceived as being more lively. The present invention does not attempt to reproduce the fine structure of any particular instrument. What is thought to be important is simply that some complicated fine structure be present. For each instrument of a stringed quartet, multiple loudspeakers can be used. Each speaker is driven by a weighted mixture of bridge and F-hole signals with possible inversion. The resulting interference pattern leads to the fine structure of the instrument. At this time, the weighting functions and decisions to invert are tuned by ear. Thus, at step 301, the instrument is selected and at step 302, the contact recording reproduction is matched by ear.

There are numerous alternative implementations of the present invention. For bowed string instruments, the individual radiation pattern can be simulated by comb filtering as in existing mono to stereo converters. In this case, it is adequate to record a single channel for each instrument and tight-miking might be used instead of contact pickups. For brass and woodwind instruments, the recordings can be made with mouthpiece pickups. After filtering, these

recordings are reproduced through characteristic loudspeakers. Brass instruments use a single piston driver of appropriate size, whereas woodwind instruments require a more complicated design.

It is to be understood that the invention is not limited to the exact construction illustrated and described above, but that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A local performance simulation system comprising:

a signal generation system for simultaneously generating contact recording signals based on vibrations from an ensemble, the ensemble producing an audible ensemble sound pattern;

a signal processing system for channelizing the contact recording signals and generating final instrument signals based on the channelized contact recording signals; and

a reproduction system for generating audible sound waves based on the final instrument signals, the sound waves simulating the ensemble sound pattern.

2. The simulation system of claim 1 wherein the ensemble includes a plurality of instruments.

3. The simulation system of claim 2 wherein the plurality of instruments includes a string quartet.

4. The simulation system of claim 2 wherein the signal generation system includes a plurality of contact recording configurations.

5. The simulation system of claim 4 wherein each contact recording configuration includes a pair of contact transducers coupled to a corresponding instrument at a location governed by a cross-correlation function as measured in different frequency bands.

6. The simulation system of claim 5 wherein the pair of contact transducers includes:

a first transducer located below an f-hole of the corresponding instrument, the first transducer generating a contact recording signal based on vibrations near the f-hole; and

a second contact transducer located under a bridge of the corresponding instrument, the second transducer generating a contact recording signal based on vibrations near the bridge.

7. The simulation system of claim 1 wherein the signal processing system includes:

a storage system for storing the contact recording signals to a storage medium as channelized data; and

a retrieval system for retrieving the channelized data from the storage medium.

8. The simulation system of claim 7 wherein the storage system includes:

an analog to digital conversion system for generating digital recording signals based on the contact recording signals; and

a recording system for generating the channelized data based on the digital recording signals, the recording system recording the channelized data to the storage medium.

9. The simulation system of claim 8 wherein the retrieval system includes:

an equalization system for tailoring a frequency response of the channelized data;

a mixing system for generating intermediate instrument signals based on the channelized data;

a digital to analog conversion system for generating final instrument signals based on the intermediate instrument signals; and

an amplifier for amplifying the final instrument signals.

10. The simulation system of claim 2 wherein the reproduction system includes:

a plurality of loudspeaker systems, each loudspeaker system having a corresponding instrument and generating audible sound waves which approximate a frequency dependence of radiation from front, back and side surfaces of the assigned instrument; and

a means for simulating musician absorption of the audible sound waves.

11. The simulation system of claim 10 wherein each loudspeaker system includes:

a front driver having a predetermined front piston diameter for approximating the frequency dependence of radiation from front and side surfaces of the assigned instrument;

a back driver having a predetermined rear piston diameter for approximating the frequency dependence of radiation from back and side surfaces of the assigned instrument.

12. A method for simulating a local performance of an ensemble, the method comprising the steps of:

simultaneously generating contact recording signals based on vibrations from the ensemble, the ensemble producing an audible ensemble sound pattern;

channelizing the contact recording signals;

generating final instrument signals based on the channelized contact recording signals; and

generating audible sound waves with a reproduction system based on the final instrument signals, the sound waves simulating the ensemble sound pattern.

13. The method of claim 12 wherein the ensemble includes a plurality of instruments.

14. The method of claim 13 wherein the plurality of instruments includes a string quartet.

15. The method of claim 13 further including the step of coupling a pair of contact transducers to a corresponding instrument at a location governed by a cross-correlation function as measured in different frequency bands.

16. A method for tuning a local performance simulation system, the method comprising the steps of:

matching a system overall frequency response to a known overall frequency response;

matching a system coarse asymmetrical frequency response to a known coarse asymmetrical frequency response; and

approximating a system fine asymmetrical frequency response to a known fine asymmetrical frequency response such that the system overall frequency response, the system coarse asymmetrical frequency response and system fine asymmetrical frequency response approximating a frequency response of an audible ensemble sound pattern produced by an ensemble.

17. The method of claim 16 further including the steps of:

selecting an instrument from the ensemble;

playing scales on the instrument;

simultaneously generating a contact recording and a microphone recording based on the ensemble sound pattern; and

comparing spectral characteristics of the contact recording and the microphone recording.

18. The method of claim 16 further including the steps of:

selecting an instrument from the ensemble;

playing scales on the instrument;

generating a contact recording based on the ensemble sound pattern; and

comparing spectral characteristics of the contact recording with a predetermined reference spectrum.

19. The method of claim 16 further including the steps of:

selecting an instrument from the ensemble;

playing scales on the instrument;

generating a contact recording based on the ensemble sound pattern; and

manually adjusting spectral characteristics of the contact recording.

20. The method of claim 16 wherein the ensemble is a string quartet.

A PROCESS FOR HIGH FIDELITY SOUND RECORDING AND REPRODUCTION OF MUSICAL SOUND

ABSTRACT OF THE DISCLOSURE

A local performance simulation system simulates an ensemble sound pattern. The simulation system includes a signal generation system for simultaneously generating contact recording signals based on vibrations from the ensemble, where the ensemble produces an ensemble sound pattern. A signal processing system channelizes the contact recording signals and generates final instrument signals based on the channelized contact recording signals. The simulation system further includes a reproduction system with dedicated loudspeaker systems for generating audible sound waves based on the final instrument signals, where the sound waves simulate the ensemble sound pattern. Contact recording the vibrations and channelizing the contact recording signals eliminates all reverberation and reflection effects of the recording environment from the contact recording signals. Using a dedicated loudspeaker system for each instrument in the ensemble allows the simulation system to capture the reflection and reverberation effects of the listening environment, and creates the impression that the ensemble is present in the listening environment.

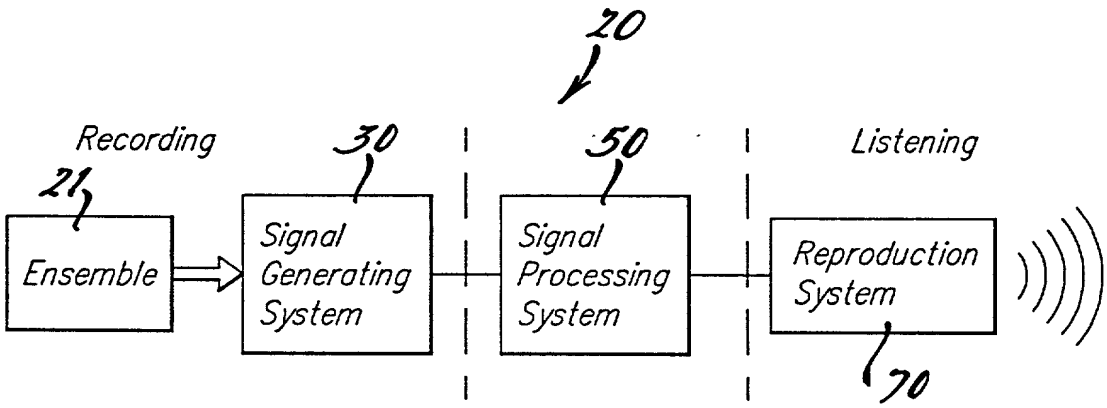
20
Recording
21
Ensemble
30
Signal Generating System
50
Signal Processing System
Listening
Reproduction System
70

Fig. 1.

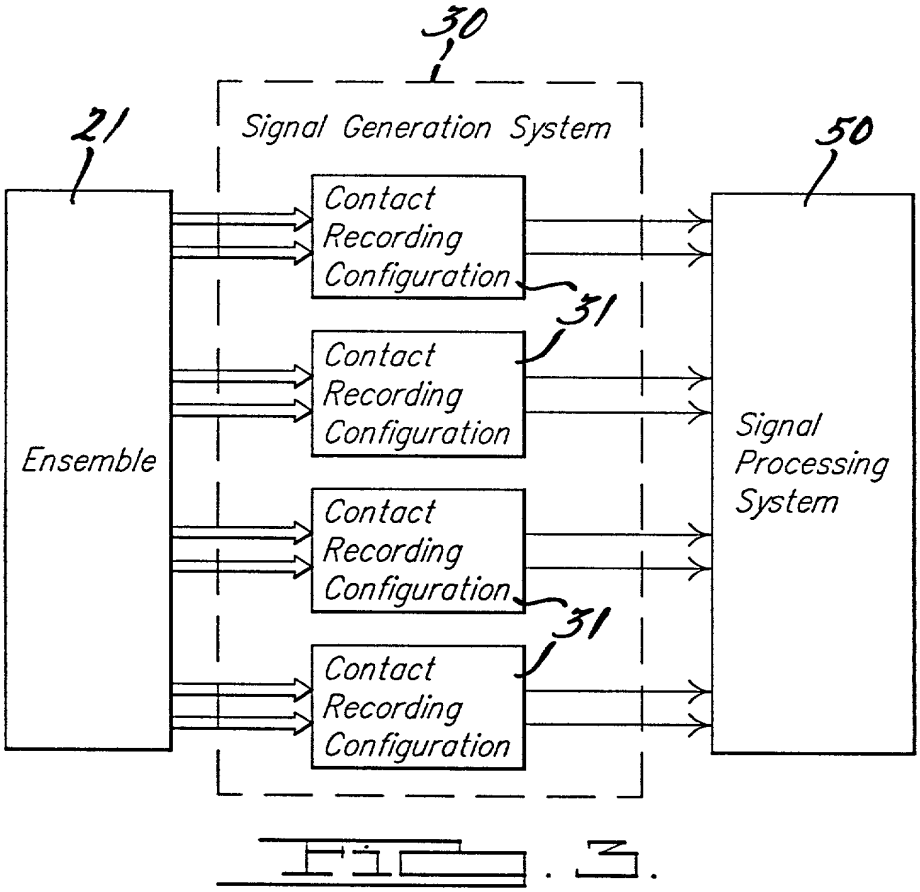
30
Signal Generation System
21
Ensemble
Contact Recording Configuration
31
Contact Recording Configuration
Contact Recording Configuration
31
Contact Recording Configuration
50
Signal Processing System

Fig. 3.

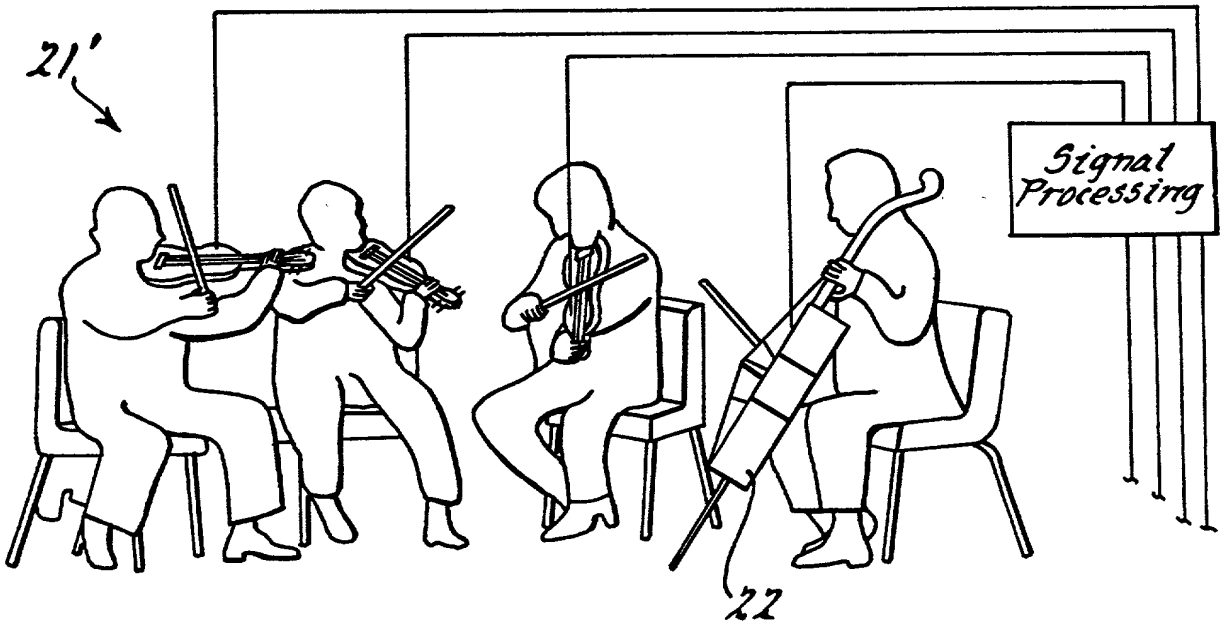

Fig. 2.

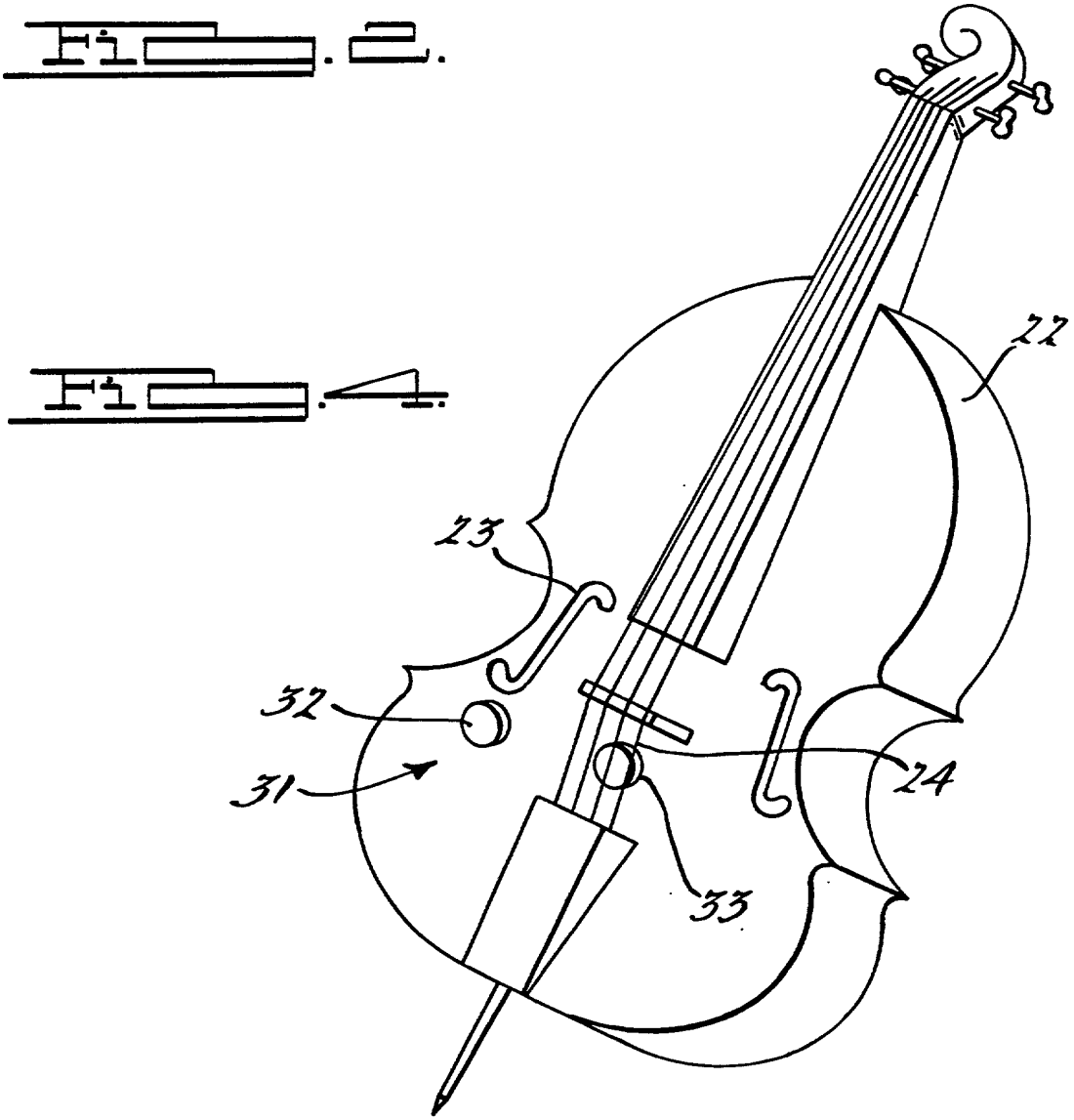

Fig.

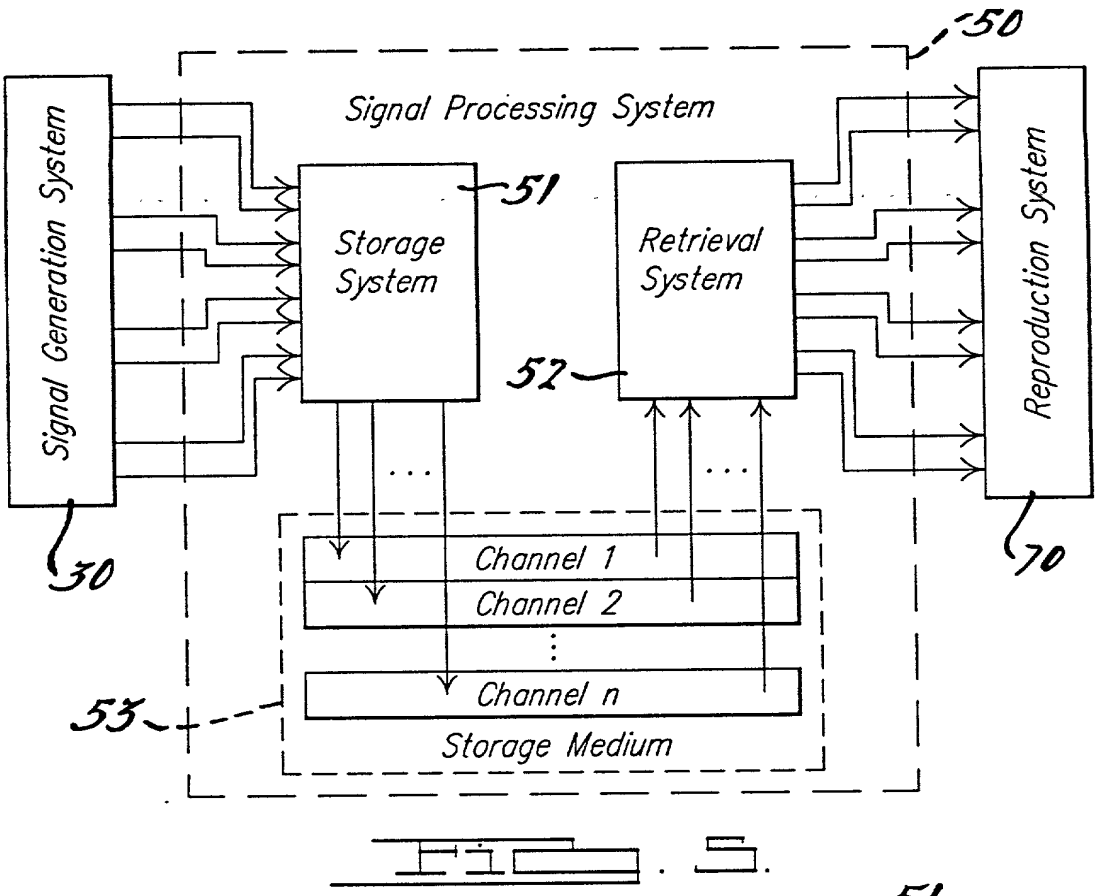
50
Signal Processing System
Signal Generation System
Storage System
51
Retrieval System
52
Reproduction System
30
70
Channel 1
Channel 2
Channel n
53
Storage Medium

FIG. 5.

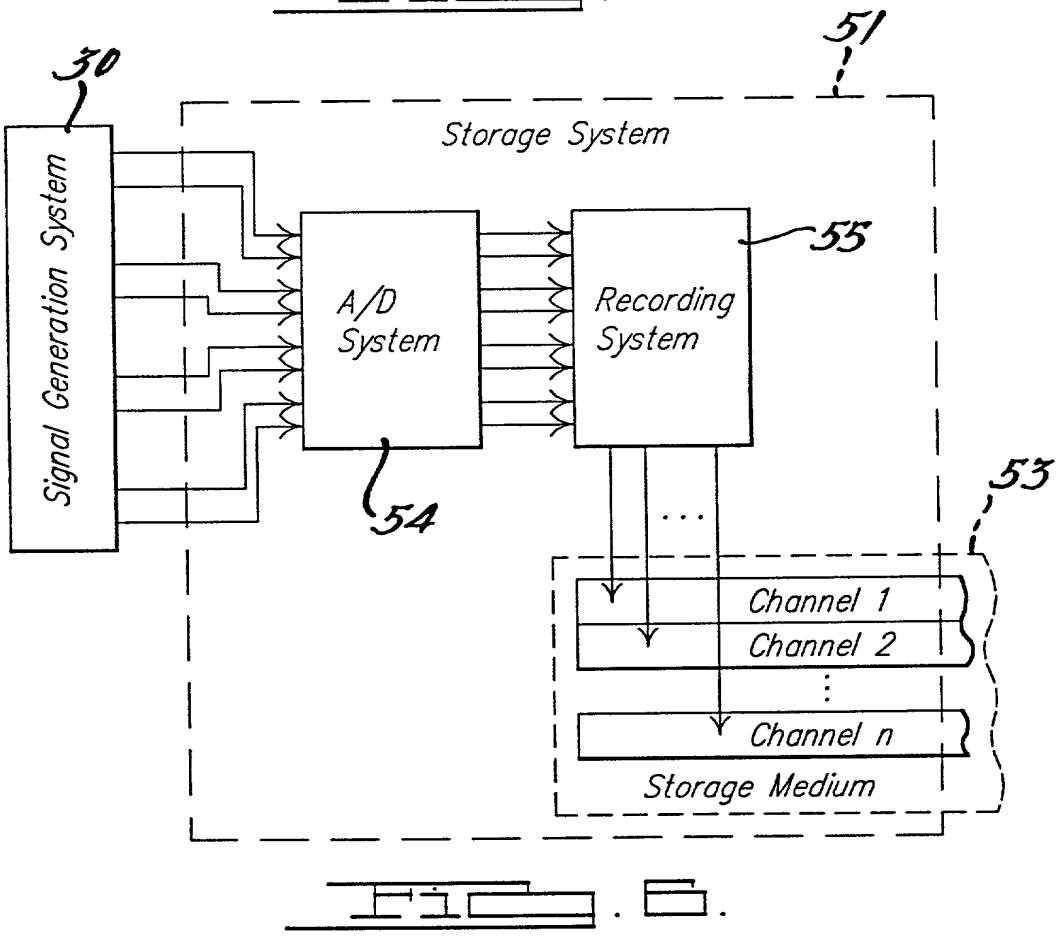
51
30
Storage System
Signal Generation System
A/D System
54
Recording System
55
53
Channel 1
Channel 2
Channel n
Storage Medium

FIG. 6.

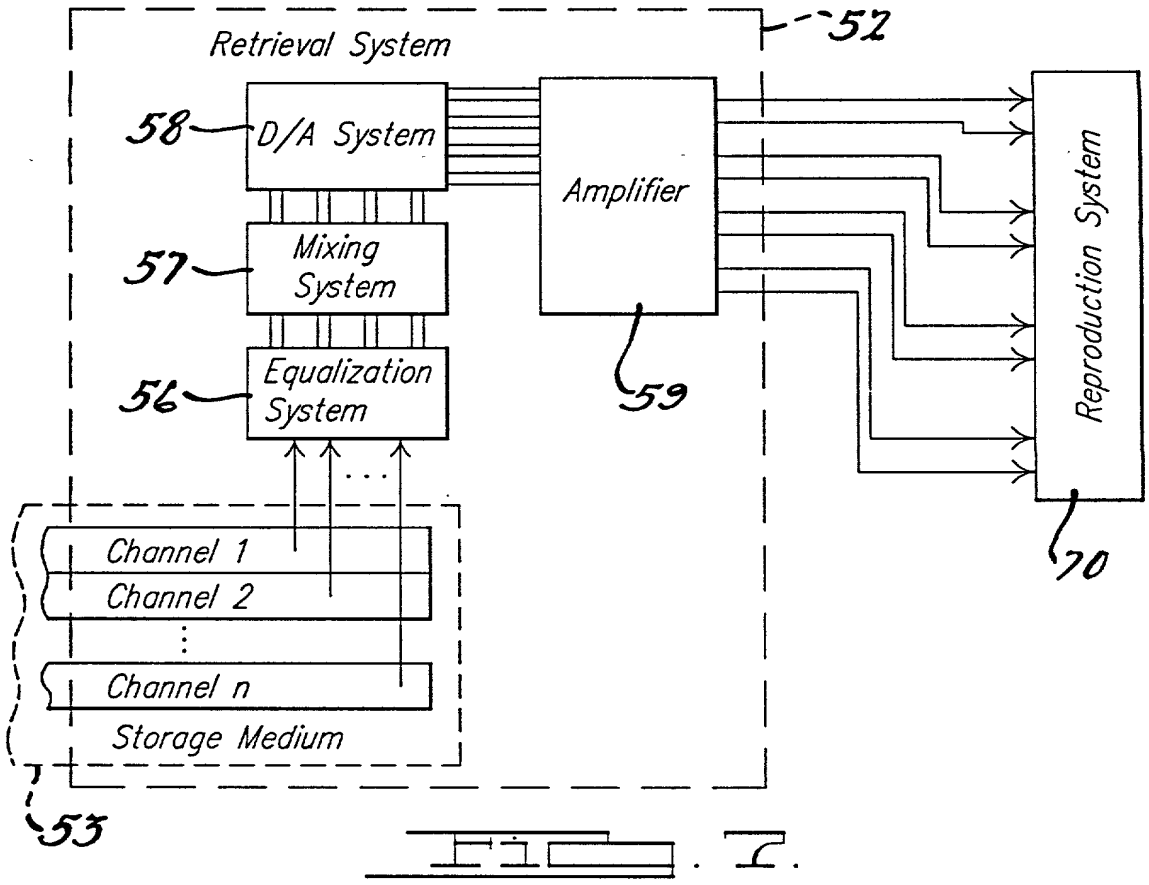
Retrieval System
52
58
D/A System
Amplifier
Reproduction System
57
Mixing System
56
Equalization System
59
70
Channel 1
Channel 2
Channel n
Storage Medium
53

FIG. 1.

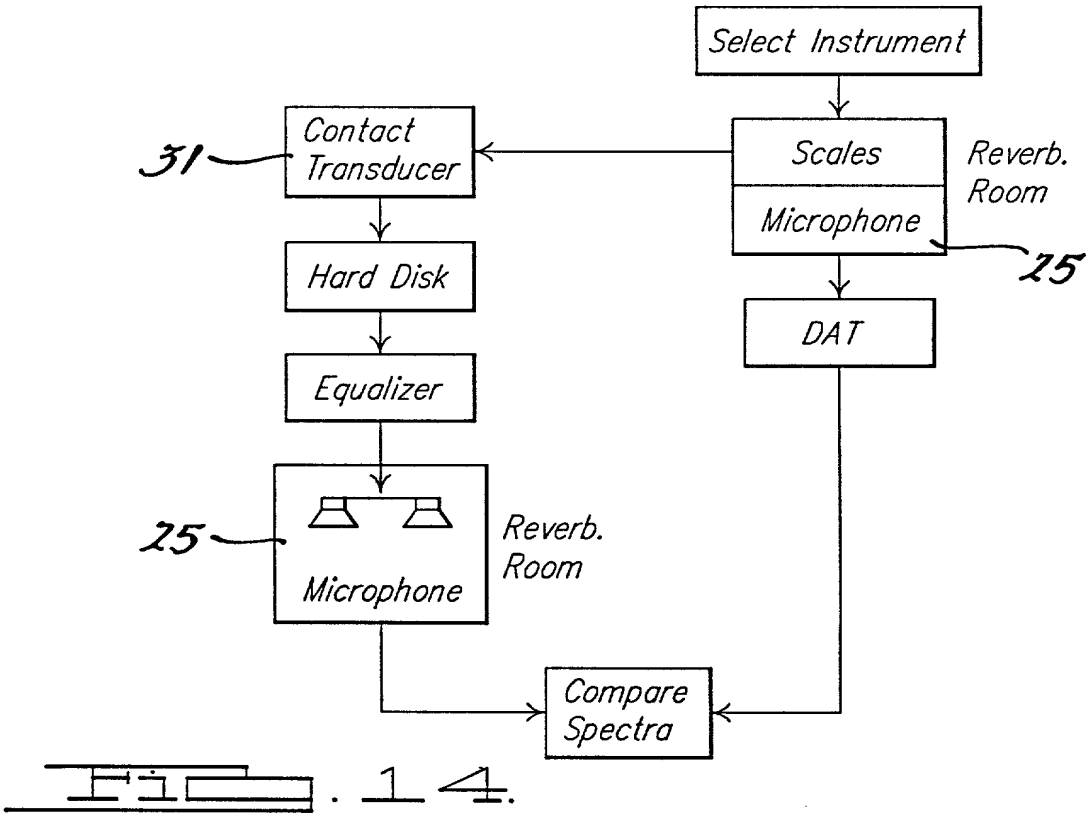
Select Instrument
31
Contact Transducer
Scales
Microphone
Reverb. Room
15
Hard Disk
DAT
Equalizer
25
Microphone
Reverb. Room
Compare Spectra

FIG. 14.

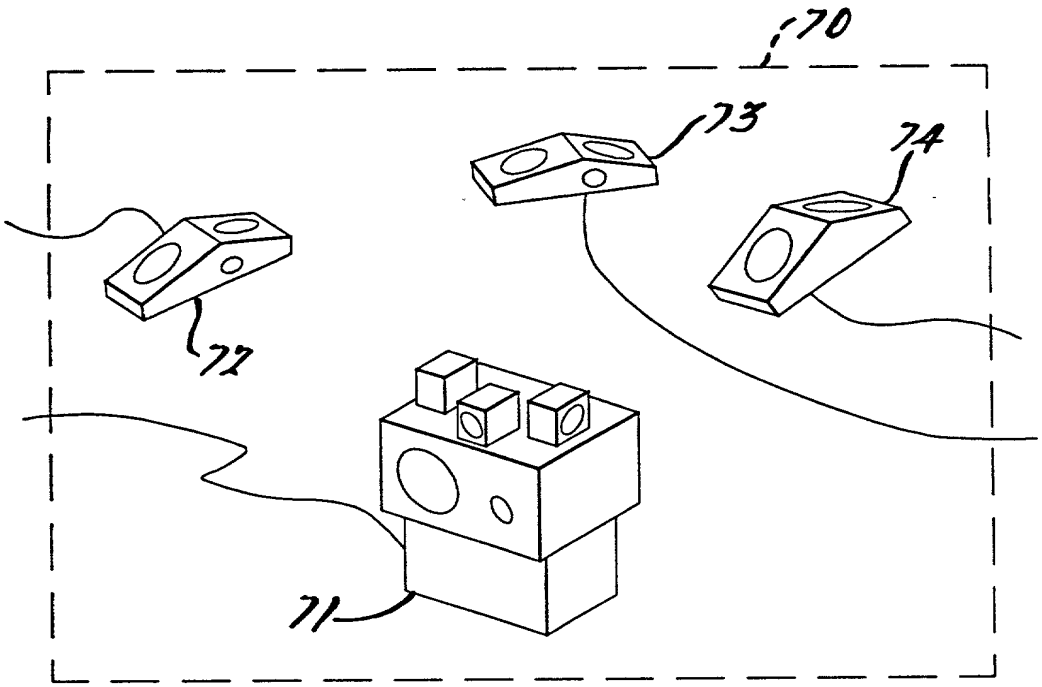

FIG. 8.

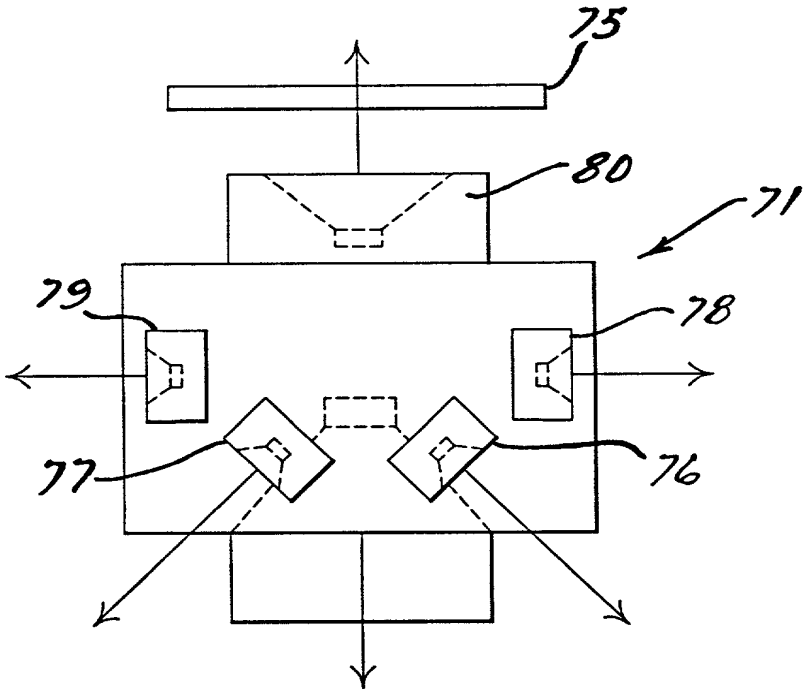

FIG. 9.

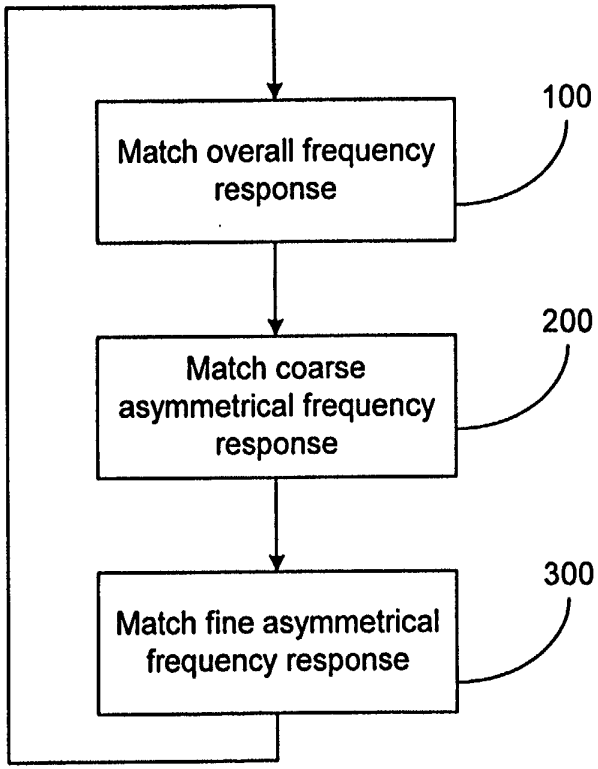

Figure 10

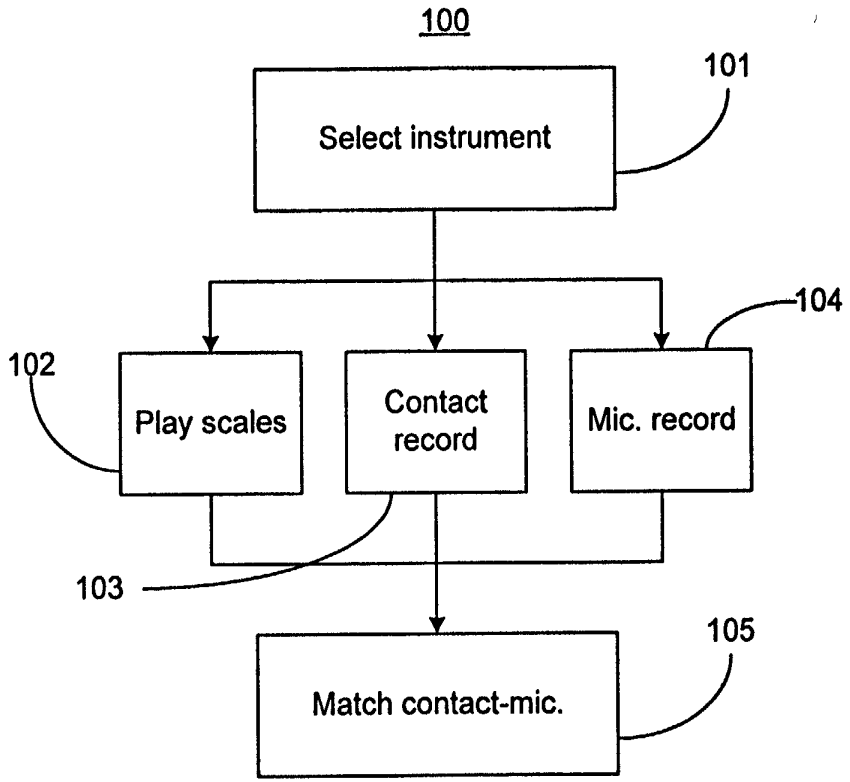

Figure11

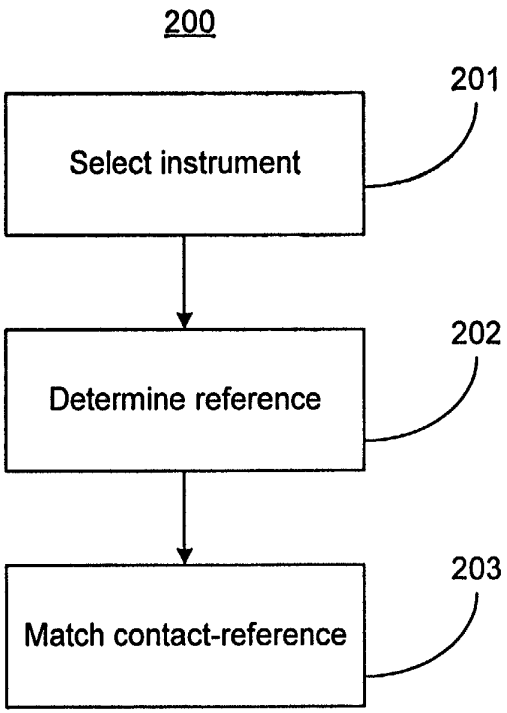

Figure 12

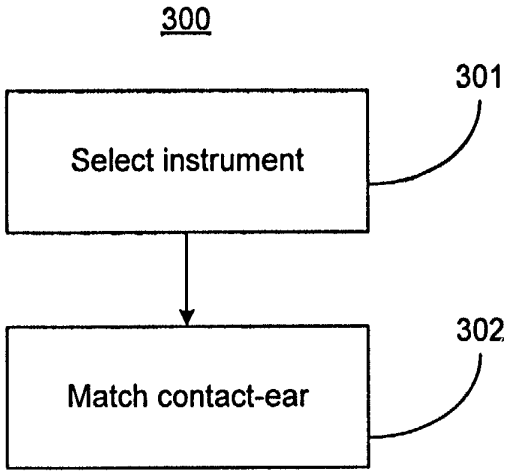

Figure 13

Attorney Docket No. 6550-000043

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A PROCESS FOR HIGH FIDELITY SOUND RECORDING AND REPRODUCTION OF MUSICAL SOUND

the specification of which (check one)

[X] is attached hereto.

[ ] was filed on _____ as Application Serial No. _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information that is material to the patentability of the invention claimed in this application, or information that is material to the examination of this application, in accordance with Title 37, Code of Federal Regulations, section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, section 119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

			Priority Claim	
(Number)	(Country)	(Day/Month/Year filed)	Yes	No
(Number)	(Country)	(Day/Month/Year filed)	Yes	No
(Number)	(Country)	(Day/Month/Year filed)	Yes	No

DECLARATION AND POWER OF ATTORNEY

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States Provisional application(s) listed below:

PRIOR PROVISIONAL APPLICATIONS

(application serial number)	(Month / Day / Year filed)
(application serial number)	(Month / Day / Year filed)

I hereby claim the benefit under Title 35, United States Code, section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	**Filing Date**	**Status - patented, pending, abandoned**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint Ronald L. Hofer, Reg. No. 26,467, Gregory A. Walters, Reg. No. 41,366, and each principal, attorney of counsel, associate and employee of Harness, Dickey & Pierce, P.L.C., who is a registered Patent Attorney, my attorney with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith. I request the Patent and Trademark Office to direct all correspondence and telephone calls relative to this application to Harness, Dickey & Pierce, P.L.C., P. O. Box 828, Bloomfield Hills, Michigan 48303 (248) 641-1600.

Full name of sole or first inventor: Willilam M. Hartmann

Inventor's signature: William M. Hartmann

Date: 11 Feb 00

Residence: 749 Beech Street, East Lansing, Michigan 48823

Citizenship: United States of America

Post Office Address: _____

Attorney Docket No. 6550-000043

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art Unit:	Not yet assigned	
Examiner:	Not yet assigned	
Inventor(s):	William M. Hartmann	**ESTABLISHMENT OF ASSIGNEE'S RIGHT TO PROSECUTE APPLICATION UNDER 37 C.F.R. § 3.73(b), AND POWER OF ATTORNEY**
Serial No.	Not yet assigned	
Filed:	herewith	
For:	A Process For High Fidelity Sound Recording And Reproduction Of Musical Sound	

Hon. Commissioner Of Patents & Trademarks
Washington, D. C. 20231

Sir:

Under 37 C.F.R. § 3.73(b), the undersigned hereby establishes the below-named Assignee's ownership in the above-identified Application:

Assignee: Board of Trustees operating Michigan State University
East Lansing, Michigan 48824

The documentary evidence of a chain of title from the original owner to the Assignee is provided in the Assignment Document(s):

_X_ filed herewith.

____ previously filed,

Reel No. _____, Frame No. _____.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the

United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Assignee furthermore hereby appoints Ronald L. Hofer, Reg. No. 26,467, Gregory A. Walters, Reg. No. 41,366, and each other principal, attorney of counsel, associate and employee of Harness, Dickey & Pierce, P.L.C., who is a registered Patent Attorney, as attorney of record, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith. I request the Patent and Trademark Office to direct all correspondence and telephone calls relative to this application to Harness, Dickey & Pierce, P.L.C., P. O. Box 828, Bloomfield Hills, Michigan 48303 (telephone 248-641-1600).

The undersigned (whose title is supplied below) is empowered to sign this certificate on behalf of the assignee.

Daniel T Evon

Name: Daniel T. Evon

Title: Director, Contracts and Grants

Date: 2/15/00

Assignee: Board of Trustees operating Michigan State University